Rejection of Claims 13-24 Under 35 U.S.C § 102(b)

Claims 13-24 stand rejected under 35 U.S.C. § 102(b). It is contended that these claims are unpatentable over Brosche et al (DE 19963005 A1). Applicants respectfully submit that this rejection should be withdrawn for at least the following reasons.

Claim 13 as presented relates to a device for measuring a clearance distance and a speed of an object using radar pulses, comprising: *a receiver-side mixer* that correlates received radar pulses with delayed transmitter-side radar pulses; *a control device* for specifying range gates within which radar pulses that are to be supplied to the mixer are continuously changeable increasingly and/or decreasingly with respect to their pulse delay; *a switchover device* for at least one of: a) implementing a plurality of operating modes for holding constant transmitter-side radar pulses that are able to be supplied to the mixer with respect to their delay, in order to measure Doppler frequencies, b) for one of resetting and raising the delay to one of a current starting value and a new starting value, and c) for producing a continuous delay into a direction that runs opposite to a preceding change; and *an evaluating device* for determining distance and speed values in response to an output signal from the mixer.

It is respectfully submitted that Brosche does not disclose or even suggest the feature of a switchover device. Indeed, Brosche does not even discuss any type of switchover device. Instead, Brosche merely states that, using a number of successive measurements, recording of the relative speed of the object could also be carried out, and a speed measurement could also take place using the evaluation of the Doppler effect. (See page 8, lines 18-21, of English translation.) Also, that different *distance* ranges may be evaluated sequentially and/or in parallel. (See page 3, lines 10-11.) There is no mention of speed measurements associated with a switchover device. Without an intelligent switchover device,

measuring conflicts may occur. Additionally, a mode switchover from clearance measuring (EM) to speed measuring (GM) is not able to take place at just any time. This may cause time delays when there is a continuous change of the transmitter-side radar pulses supplied to the mixer.

According to the Examiner, Brosche figures 2-4 and 8 purportedly disclose a switchover device for doing one or more of the following: a) implementing a plurality of operating modes for holding constant transmitter-side radar pulses that are able to be supplied to the mixer with respect to their delay, in order to measure Doppler frequencies, b) for one of resetting and raising the delay to one of a current starting value and a new starting value, and c) for producing a continuous delay into a direction that runs opposite to a preceding change. However, in contrast to the Examiner's assertion, these figures do not disclose a "switchover device." Although they may show switches, there is no switchover device that performs any of the above functions.

As indicated above, Brosche does not disclose, or even suggest, all of the features recited in claim 13. As such it is respectfully submitted that Brosche does not anticipate claim 13.

Claims 14-24 ultimately depend from claim 13 and therefore include all of the features recited in claim 13. It is therefore respectfully submitted that Brosche does not anticipate any of these dependent claims for at least the same reasons set forth above in support of the patentability of claim 13.

In view of the foregoing, withdrawal of this rejection is respectfully requested.

Rejection of Claim 22 Under 35 U.S.C § 103(a)

Claim 22 stands rejected under 35 U.S.C. § 103(a) as unpatentable over Brosche et al (DE 19963005 A1) in view of Mende (DE 19833327 A1).

To reject a claim as obvious under 35 U.S.C. § 103(a), the prior art must disclose or suggest each claim feature, and the prior art must also provide a motivation or suggestion for combining the features in the manner contemplated by the claim. (See Northern Telecom, Inc. v. Datapoint Corp., 908 F.2d 931, 934 (Fed. Cir. 1990), cert. denied, 111 S. Ct. 296 (1990); In re Bond, 910 F.2d 831, 834 (Fed. Cir. 1990)).

Claim 22 was rejected under 35 U.S.C. § 103(a) as unpatentable over Brosche in view of Mende. It is respectfully submitted that even if it were proper to combine the references as suggested (which is not conceded), the secondary Mende reference does not cure the critical deficiencies of the Brosche reference (as explained above) as applied against claim 13, from which claim 22 depends. Indeed, the Office Action does not even assert that the Mende reference cures the critical deficiencies of the Brosche reference as applied against claim 13. It is therefore respectfully submitted that claim 22 is allowable for essentially the same reasons that 13 is allowable. Accordingly, withdrawal of the obviousness rejection of claim 22 is respectfully requested.

CONCLUSION

In view of the foregoing, it is respectfully submitted that all of the presently pending claims are allowable. It is therefore respectfully requested that the rejections be withdrawn since they have been obviated. All issues raised by the Examiner having been addressed, an early and favorable action on the merits is respectfully submitted.

Respectfully submitted,

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TRANSLATION OF LAID-OPEN DOCUMENT DE 199 63 005 A1

METHOD AND DEVICE FOR ACQUIRING AND EVALUATING OBJECTS IN THE AREA SURROUNDING A VEHICLE

Description

Background Information

The present invention relates to a method and to a device for acquiring and evaluating objects in the area surrounding a vehicle, using a close-range radar according to the preamble of the method claim and of the device claim.

It is known from DE 44 42 189 A1, for example, that in a system for distance measurement in the area surrounding motor vehicles, sensors are used having send and receive units for sending and receiving information. With the aid of the distance measurement, passive protective measures for vehicles can be activated in response to a front, side or rear collision. By exchanging the registered information, traffic situations may be judged to activate appropriate deployment systems, for example.

In addition, it is generally known per se that a distance measurement may be performed using a pulsed radar, in which a carrier pulse having a square wave envelope of an electromagnetic oscillation is emitted in the gigahertz range. This carrier pulse is reflected from the target object, and the target distance may be determined from the time span between the emission of the pulse and the incidence of the reflected radiation, and the relative speed of the target object may also easily be determined with restrictions by

making use of the Doppler effect. Such a measuring principle is described, for example, in the textbook of A. Ludloff, "Handbuch Radar und Radarsignalverarbeitung", (Handbook of Radar and Radarsignal Processing), pp. 2-21 to 2-44, Vieweg Verlag, 1993.

For the safe control of the passenger safety systems in a motor vehicle mentioned at the outset, as a rule, a plurality of radar sensors are required for the individual conflict situations in the area surrounding the motor vehicle. Early detection of a collision (precrash detection) is essential for enabling early recording of an object which represents danger to the passengers in case of a collision. In this way, it should be possible to activate protective systems such as an air bag, a seat-belt tensioner, or a side air bag in a timely manner, in order thus to achieve the greatest possible protective effect.

The recording and/or monitoring of the traffic situation, in particular in proximity to the motor vehicle, may additionally be useful for multiple further applications. These include parking aids, aids for monitoring the so-called "blind spot," and support in "stop and go" traffic, in which the distance from the preceding vehicle is determined in order to be able to stop and go automatically. In this connection, normally a plurality of radar sensors is used, having different requirements that are respectively adapted to the measuring task, the requirements differing essentially in operating range and evaluation time, since each of these functions has specific recording ranges as well as different measuring cycle times. It is true that, in principle, so-called universal sensors may be operated in common via a specially adapted bus system and connected together with an evaluation unit, but not all distance ranges within a short range are able to be processed in an optimal way in a relatively short evaluation

time for a safe manner of functioning.

Advantages of the Invention

A method and a device for recording and evaluating objects in the area surrounding a vehicle, using a radar sensor of the type stated at the outset, is developed further according to the present invention in an advantageous manner in that the area surrounding the vehicle is recorded, using a send signal of respectively a pulsed radar sensor, in one or more receiving branches of the radar sensor, in such a way that different distance ranges may be evaluated sequentially and/or in parallel.

Advantageous specific embodiments of the method according to the present invention are given in dependent Claims 2 through 4.

It is proposed in an advantageous manner according to the present invention that, using a relatively simply constructed sending and receiving device of a pulsed radar sensor, during the recording process of the objects, at least two measurements for the carrier pulses are formed in different time slots or measuring channels, which, in turn, may be associated with different distance ranges. In this connection, a first distance range (e.g. x_0 to x_1) and an additional distance range (e.g. having $x_0 < x_1 < x_2$) may be defined. The first range x_0 to x_1 is evaluated, in this context, in response to each measurement within a measuring interval Δt, the second range may then be evaluated in further steps each in measuring intervals Δt. These distance ranges are then processed in an evaluation unit, either in parallel or sequentially. The measuring duration may be abbreviated advantageously, in this context, since the data for the lower distance range are able also to be used in the evaluation of the upper distance range.

Alternatively to the subdivision, mentioned before, of the entire distance range x_0 to x_2, that is to be monitored, into subranges, the measuring channels may also be drawn upon advantageously for a distance evaluation in a channel and an appropriately adapted speed evaluation in a second measuring channel, various algorithms being able simply to be used in the subranges during the evaluation, which make possible a distance evaluation and perhaps a special evaluation of distance and speed. In one advantageous specific embodiment of a device for carrying out the method according to the present invention, a transmitting branch is present in the pulsed radar sensor, which has an oscillator, a scaler, a switch and a transmitting antenna, using which a carrier pulse of a radar beam is able to be generated that is directed at an object that is to be recorded. There is also present a clock pulse generator whose output signal controls a pulse component, which provides the required signal for forming the carrier pulse. The output signal guided for at least one receiving branch via an adjustable pulse delay component to an additional pulse component, which generates a carrier pulse that is time-staggered compared to the carrier pulse from the first pulse component. An evaluable analog output signal is able to be generated, using a mixture of the time-staggered signal and the signal supplied by the receiving antenna, preferably using an I/Q mixer (I/Q = in-phase/quadrature).

It is particularly advantageous if the output signal of the clock pulse generator is guided, to form a second receiving branch, via a second adjustable pulse delay component to an additional pulse component, which generates a carrier pulse that is time-staggered compared to the carrier pulse from the first pulse component, using an additional switch. With this, using the second receiving branch, a parallel recording of the distance range may be carried out in a simple manner.

In another advantageous device, in a modification of the above-described specific embodiment, a double pulse is generated in the pulse component and the individual pulses of the double pulse are guided, using a two-way switch, alternately to the switches to form the respective carrier pulse in the various receiving channels. The double pulse may advantageously also be used in a device having a receiving branch, a summed integration signal being then created at the output of the mixer, which is able to be separated again by appropriate programming in one of the evaluation units.

A further advantageous specific embodiment is able to be implemented if, between the clock pulse generator and the pulse delay components, one possibility is provided in each case for pulse duration adjustment. In this instance, the duration of the carrier pulse for the transmitter and the first receiver is able to be set coincidingly using the pulse duration setting, and using the second pulse duration setting and the additional pulse delay component, a different pulse setting with respect to duration and delay may be selected for a second receiver. The spatial resolution in response to the recording of the area surrounding the motor vehicle is variable by changing the pulse duration in the reference signal.

These and further features of preferred developments of the invention are evident not only from the claims but also from the specification and the drawings; the individual features, each individually per se or severally in the form of subcombinations, can be realized in the specific embodiment of the invention and in other contexts, and can represent advantageous embodiments that are also patentable per se, for which protection is herein claimed.

Brief Description of the Drawing

The device according to the present invention, for recording and evaluating objects in the area surrounding a vehicle with the aid of a close-range radar, is explained with the aid of the exemplary embodiments in the drawings. The figures show:

Fig. 1 a sketch of a vehicle that has a plurality of radar sensors for the close range;

Fig. 2 a block diagram of a pulse radar sensor in which different operating ranges may be recorded one after another in specified time slots;

Fig. 3 a diagram showing the distance ranges recorded one after another in the time slots, according to the exemplary embodiment, as in Figure 2;

Fig. 4 a block diagram of a pulse radar sensor in which different operating ranges may also be recorded in parallel receiving branches in specified time slots;

Fig. 5 a modification of the example as in Figure 4, having only one receiving antenna for two receiving channels;

Fig. 6 a modification of the example as in Figure 4, having only one receiving antenna for two receiving channels and a switchable time delay of the carrier pulse of the pulse radar in the receiving branch;

Fig. 7 a block diagram of a pulse radar sensor in accordance with that in Figure 2, in which a double pulse is provided for a time delay of the carrier pulse of the pulse radar sensor in the receiving branch, and

Fig. 8 a modification of the exemplary embodiment as in Figure 7, having in each case an additional setting of the pulse duration of the carrier pulse of the

pulse radar sensor.

Description of the Exemplary Embodiment

Figure 1 shows schematically a sketch of a vehicle 1, on which at the front, rear and side sections radar sensors 2, preferably pulse radar sensors, are mounted for recording and evaluating the near area surrounding vehicle 1. By the use of radar sensors 2, a passenger protection system that was mentioned at the outset may be implemented which makes possible precrash detection, for example, and beyond that, is also able to activate protection systems such as air bags, belt tensioners or side air bags.

In the exemplary embodiment shown, traffic situations in the near area surrounding the vehicle may be detected. Radar sensors 2 are operated in common via a specially adapted bus system 3, and are interconnected with evaluation units 4, in which the data gathered are evaluated and appropriate safety systems may be intelligently activated.

Figure 2 shows a block diagram of a first exemplary embodiment of a pulse radar 2 with its essential components which are important for the explanation of its function. An oscillator 10 is present, for generating an oscillation in the microwave range, for instance, at 24 GHz or other frequencies commonly used in radar technology. The output signal of oscillator 10 is guided to a switch 12 by a scaler 11. Using switch 12, the microwave signal is able to reach a transmitting antenna 13, by which the radar beams are able to be directed at the object that is to be recorded, for instance in response to mounting it on the outer region of a vehicle 1 as in Figure 1.

Switch 12 from Figure 2 is used to form a carrier pulse, by which a specified number of oscillations of oscillator 10 may be emitted. There is also present a clock pulse generator 14

for generating the switching signal, whose output signal controls a pulse component 15, which provides the required signal for forming the carrier pulse. The output signal of clock pulse generator 14 is also guided via an adjustable pulse delay component 16 to an additional pulse component 17, which generates a carrier pulse that is time-staggered to the carrier pulse from pulse component 15. Using the time-staggered carrier pulse, the signal of oscillator 10 present at the other output of scaler 11 is now switched by switch 18. At mixer 19, there are present for one thing, the time-staggered signal from the output of switch 18 and the radar echo received by a receiving antenna 20 of the carrier pulse transmitted by transmitting antenna 13.

An output signal 21 at the output of mixer 19 may now be evaluated to see whether, in the distance range specified by the time staggering of delay element 16, a radio echo reflected by an object is being received, having an appropriate travel time. Using a number of successive measurements, recording of the relative speed of the object could also be carried out, and a speed measurement could also take place using the evaluation of the Doppler effect.

In the diagram in Figure 3, one may see a first exemplary embodiment of a measuring method according to the present invention, in this case, the distance in meters being plotted against time in milliseconds. A meaningful subdivision of the recording of the distance ranges is performed, in this context, by a suitable sequential measuring at specified intervals. In a first measuring time 22 of a measuring interval Δt, first of all a first lower distance range 24 is recorded which, in this case, extends up to x_1. In a second measuring time 23, sequentially a second distance range 25 (up to x_2) is evaluated, in this case, a time of the measuring interval of Δt, that is required for many application cases,

being always maintained.

First range 24 is evaluated, in this context, in each measuring interval of Δt, the upper range 25 may then be recorded in further steps, in each case in time slots of the measuring interval of Δt, sequentially up to maximally x_0 **[sic; x_n]** in this instance. The data of the distance ranges measured before, in each case, may always be drawn upon respectively, in this context, as may be recognized from the lines drawn in bold for the measuring times according to Figure 3, so that, overall, an abbreviation of the measurement comes about. The result of upper distance range 25, in the exemplary embodiment shown, may in any case be available within a time span (e.g. t_{meas}), which is sufficient for optimal evaluation in the application cases mentioned.

Carrying out the method described above may be done with the aid of the radar sensor described in Figure 2, without any additional hardware expenditure. Measuring times 22, 23 or measuring intervals Δt and the distance ranges may be set by appropriate clock pulsing of pulse component 17 and by a variable time delay in pulse delay component 16. The required synchronization during the measurement may be ensured using a correspondingly constructed evaluation unit.

Alternatively to the previously described sequential recording of the entire distance ranges 24, 25, a parallel evaluation of distance ranges 24, 25, that will be explained with the aid of Figure 4, may also be carried out. In this case, the receiving branch of the radar sensor, described in Figure 2, is doubled. Consequently, a pulse delay component 30, a pulse component 31, a switch 32, a mixer 33 and a receiving antenna 34 are present, which function in a comparable manner to components 16, 17, 18, 19 and 20 as in Figure 2. In addition, in this instance, preamplifiers 35 and 36 have been connected between

receiving antennas 20, 34 and mixers 19, 33, which, however, are not absolutely necessary for the functioning of the system.

In the case of this exemplary embodiment as in Figure 4, lower distance range 24 in the receiving branch is evaluated using components 16 to 20 within measuring interval Δt and the upper distance range is recorded in parallel to it using components 30 to 34 within time span t_{meas}. By the parallel processing of the different distance ranges, one eliminates particularly the power loss based on shorter measuring times in the sequential evaluation of data in the exemplary embodiment as in Figure 2.

The exemplary embodiment as in Figure 5, in modification of the system in Figure 4, has only one receiving antenna 20, a power splitter 37 having to be provided in this case which causes a ca. 3 dB power loss, but, on the other hand, the installation space is able to be kept small when using only one receiving antenna. In order to improve the power, here too a preamplifier 36, or perhaps several preamplifiers, may be connected behind receiving antenna 20.

Figure 6 shows an exemplary embodiment in which systems according to Figures 4 and 5 are constructed using parallel receiving branches having only one pulse delay component 16 and one pulse component 17. Pulse component 17 generates a double pulse in this case, which is switched alternately by a change-over switch in two ways respectively to the two receiving branches. By doing this, two individual pulses are generated on the receiving side during a pulse repetition on the transmission side. Consequently, a function is made possible that is comparable to the systems as in Figure 4 and 5, while saving components, an appropriate synchronization having to be provided in the signal evaluation, however.

The double pulse generation according to Figure 6 may also be

used in an exemplary embodiment as in Figure 7, in which only one receiving branch is provided, corresponding to Figure 2. Consequently, pulse component 17 generates a double pulse here too, which is processed in only one receiving branch. In the evaluation of the signal at output 21 of mixer 19, a summed integration signal is created in this case, however, so that for the separation of this signal, the various receiving cells are able to be processed, for example, according to a so-called pseudo-noise coding according to various sequences. Separating the summed items may then be achieved by appropriate programming in one of the evaluation units.

In Figure 8 a system is shown schematically which also provides a dual channel receiving unit, additionally, however, the pulse duration of the signal generated by clock pulse generator 14 being changed. On the one hand, in this instance, using a pulse duration setting 40, the duration of the carrier pulse for a transmitter 41 and a first receiver 42 are set in a matching manner, the pulse delay taking place using a component 43 analogous to the one described before. On the other hand, using a second pulse duration setting 44, and an additional pulse delay component 45 a different pulse setting is made with respect to duration and delay for a second receiver 46. The signal of the receiving antenna is split up via a divider 47 to receivers 42 and 46.

Using this system shown in Figure 8, while utilizing the same send signal, a spatial resolution may be gathered that is different in several receiving channels. The spatial resolution is variable, in this context, because of the change in the in the pulse width in the reference signal.

The exemplary embodiments described here are able to be varied, especially with respect to the number of receiving channels and of receiving branches, and the receiver

components used in common or separately, without essentially changing the function according to the present invention. A combination of sequential and parallel evaluation of the various distance ranges, that deviates from the exemplary embodiments, is also possible. Furthermore, in the evaluation of the data of the various distance ranges, possibly not all distance data have to be scanned, so as to save measuring time because of the power loss occurring at the fourth power of the distance. In that case, however, the distance data would have to be constantly checked up to the first relevant change.

What Is Claimed Is:

1. A method for recording and evaluating objects in the area surrounding a vehicle (1), in which

   - the objects are recorded using at least one radar sensor (2) and the distance data and/or the speed data of the objects are evaluated using at least one evaluation unit (4),

   wherein

   - the area surrounding the vehicle (1) is recorded while utilizing a transmission signal in each case of one pulse radar sensor (2) in one or a plurality of receiving branches (16, 17, 18, 19, 20; 30,31, 32, 33, 34) in such a way that different distance ranges (24, 25) are evaluated sequentially and/or in parallel.

2. The method as recited in Claim 1, wherein

   - in a first measuring time (22) a first distance range (24) and in a second measuring time (23) of a measuring interval a second distance range (25) is recorded,

   - the first distance range (24) being evaluated in each measuring interval and the second distance range (25) being recorded sequentially in additional steps in the subsequent measuring intervals in each case in the second measuring time (23), while drawing upon the part respectively measured before of the second distance range (25).

3. The method as recited in Claim 2, wherein

- the evaluation of the first (24) and the second distance range (25) takes place one after the other.

4. The method as recited in Claim 2, wherein

   - the evaluation of the first distance range (24) takes place in a first receiving branch (16, 17, 18, 19, 20) and the evaluation of the second distance range (25) takes place in parallel to it **[in]** a second receiving branch (30, 31, 32, 33, 34).

5. A device for carrying out the method as recited in one of the preceding claims, wherein

   - a transmitting branch is present in the pulse radar sensor (2) which has an oscillator (10), a scaler (11), a switch (12) and a transmitting antenna (13), using which a carrier pulse of a radar beam is able to be generated, which is able to be directed at an object that is to be recorded;

   - a clock pulse generator (14) is present whose output signal controls a pulse component (15), which provides the required signal for the formation of the carrier pulse, and, for at least one receiving branch is guided via an adjustable pulse delay component (16) to an additional pulse component (17) which generates a carrier pulse that is time-staggered compared to the carrier pulse from the pulse component (15); and

   - a mixer (19) is present for mixing the time-staggered signal and the signal supplied by the receiving antenna (20).

6. The device as recited in Claim 5, particularly for

carrying out the method as recited in Claim 4, wherein

- the output signal of the clock pulse generator (14), to form a second receiving branch, is guided via an adjustable pulse delay component (30) to an additional pulse component (31), which, using an additional switch (32), generates a carrier pulse that is time-staggered compared to the carrier pulse from the pulse component (15); and

- a mixer (33) is present for mixing the signal thus time-staggered and the signal supplied by a receiving antenna (20; 35).

7. The device as recited in Claim 5, particularly for carrying out the method as recited in Claim 4, wherein

- the output signal of the clock pulse generator (14), for the formation of a second receiving branch, is guided via the adjustable pulse delay component (16) to the pulse component (17), which generates a double pulse and therewith, using the switch (18) and an additional switch (32), generates a carrier pulse that is time-staggered compared to the carrier pulse from the pulse component (15), the individual pulses of the double pulse being guided using a change-over switch (38) alternately to the switches (18) and (32); and

- a mixer (33) is present for mixing the signal thus time-staggered and the signal supplied by a receiving antenna (20; 35).

8. The device as recited in Claim 5, wherein

- a double pulse is able to be generated in the pulse component (17), at an output (21) of the mixer (19) a summed integration signal being created, which is separable by an appropriate programming in one of the evaluation units (4).

9. The device as recited in Claim 6, wherein

   - between the clock pulse generator (14) and the pulse delay components (43, 45), a pulse duration setting (40, 44) is provided in each case, the duration of the carrier pulse for the transmitter (41) and the first receiver (42) being able to be set in a matching way using the pulse duration setting (40); and

   - using the second pulse duration setting (44) and the additional pulse delay component (45) a different pulse setting is able to be set with respect to the duration and the delay for a second receiver (46).

10. The device as recited in one of the Claims 5 through 9, wherein

    - the respective mixer (19, 33) is an I/Q mixer.

Abstract

A method and a device for recording and evaluating objects in the area surrounding a motor vehicle are proposed, in which the objects are recorded using at least one radar sensor (2), and the distance data and/or the speed data of the objects are evaluated in at least one evaluation unit (4). The area surrounding the vehicle (9) is recorded, in this instance, while utilizing a transmission signal in each case of one pulse radar sensor (2) in one or a plurality of receiving branches (16, 17, 18, 19, 20; 30, 32, 33, 34) in such a way that different distance ranges (24, 25) are evaluated sequentially and/or in parallel.